

**THE EFFECT OF ENVIRONMENTAL
TEMPERATURE ON THE THIAMINE
REQUIREMENT OF THE GROWING
ALBINO RAT**

BY

WILLARD BANCROFT ROBINSON

B.S., Pennsylvania State College, 1940

M.S., University of Illinois, 1942

AN ABSTRACT OF A THESIS

**SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
ANIMAL NUTRITION IN THE GRADUATE SCHOOL
OF THE UNIVERSITY OF ILLINOIS, 1943**

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I. INTRODUCTION

With the spread of the present war over the entire world, innumerable problems have arisen to harrass the army services of supply, the medical corps, and other branches of the armed forces. The effect of the various climatic conditions upon the nutritive requirements of the soldier is an important and as yet incompletely solved problem. It is evident that as environmental temperature is lowered below the critical temperature the energy requirement of a man is increased, but the effects of the environmental temperature on his requirements for proteins, minerals and vitamins has not been thoroughly investigated.

In formulating an adequate diet, the nutritionist finds the present thiamine standard one of the hardest to attain, and hence it must be given special consideration. The purpose of this study was to find a suitable method for ascertaining the thiamine requirement of the albino rat and to determine the effect of environmental temperature on that requirement.

II. EXPERIMENTAL

In order to determine the effect of environmental temperature on thiamine requirements, three different methods of attack were employed. Two of the methods were based on biological response and the third on a biochemical defect in metabolism.

The first method used was based upon the effect of thiamine upon the appetite of the animal at three different temperatures (15° C., 25° C., and 35° C.), as measured by voluntary food consumption.

The second biological approach was a measure of the effect of thiamine on food utilization as measured by differences in food consumption in pair feeding experiments where the pair mates were fed for equal rates of gain at the above three temperatures.

The biochemical approach used in the study of the problem was the measurement of the amount of pyruvic acid excreted in the urine and its relation to the level of thiamine feeding at four different temperatures, 40° C., 15° C., 25° C., and 35° C. A modification of Lu's method (1939) was used for pyruvic acid determination. Voluntary activity studies were carried out at 25° C. to determine the effect of exercise on the thiamine requirement.

In general each series consisted of eight pairs. The data of all pair-feeding tests were analyzed by the method of Student (1908).

A high carbohydrate (66.5 per cent) diet was used in all experiments. Vitamin-free casein contributed 30, corn oil 7, cod liver oil 1.5, wheat germ oil 1.0, and salts 4 per cent. Positive control rats were fed 5 micrograms of thiamine per gram of ration in all tests. Adequate supplies of riboflavin, pantothenic acid, pyridoxine, nicotinic acid, and choline were fed in their synthetic forms.

III. RESULTS AND DISCUSSION

The studies on appetite revealed no effect of environmental temperature on the thiamine requirement. An average value of 1.0 microgram per gram of food was obtained in each of the three series. The requirement at 15° C. was 0.98, at 25° C. it was 0.95, and at 35° C. it was 0.99. The average value of all rats checks precisely with the recommendation of 1.0 microgram per gram of food based on the results of growth studies made by Arnold and Elvehjem (1939).

Food utilization studies at 25° C. indicated a requirement of 0.8 microgram per gram of food. That the requirement is less than that of 1.0 microgram per gram as measured by appetite confirms the observation of Mitchell (1933) that greater food consumption of vitamin B₁ above that required for maximum food utilization as measured by body weight increase, increased the appetite of the rat. Food utilization studies at 15° C. failed to show any significant difference in utilization at levels of 0.7 and 1.0 microgram. At 35° C., the

requirement was between 1.0 and 1.4. The food utilization studies seem to confirm the observation of Mills (1941) that thiamine requirements vary directly with environmental temperature.

Pyruvic acid excretion tests indicated a requirement of between 2.0 and 2.4 micrograms per gram of food at 25° C. and 35° C. At 15° C., the requirement dropped to between 1.2 and 1.6, and at 4° C. the requirement rose again. A preferential nutrient catabolism, like that suggested by Kayser (1937), is a possible explanation for the results obtained in these experiments. Chemical regulation of body temperature may involve preferential catabolism of lipids, while physical regulation favors carbohydrate combustion.

The maximum activity of a rat was observed to occur at a level of between 2.0 and 2.4 micrograms per gram of food. The exercise had no effect on the thiamine requirement as measured by pyruvic acid excretion tests. In view of these findings it is suggested that muscular exercise would hasten the onset of thiamine deficiency only as it increased food consumption. Since maximum activity, and minimum pyruvic acid excretion occurred at the same level of thiamine feeding, it seems reasonable to assume that between 2.0 and 2.4 micrograms of thiamine per gram of a high carbohydrate ration is the optimum thiamine requirement for the rat.

The ration fed contained five Calories per gram. At 2.4 micrograms of thiamine per five Calories of dietary energy a man metabolizing 2,500 Calories would require 1.2 milligrams. Such an estimate is apt to be excessive since the metabolism of the rat is more intense than that of the human organism.

IV. SUMMARY

The effect of environmental temperatures on the thiamine requirement of the growing albino rat has been studied by the use of three different approaches: (1) Appetite studies were carried out in which the level of thiamine was sought that would provide a maximum stimulus to voluntary food consumption. (2) Food utilization experiments were conducted

by pair feeding rats for equal gains in weight. The minimum level of thiamine required to produce equal rates of gain by the pair mates was determined. (3) By the use of pair feeding tests, the thiamine requirement was measured using minimal urinary pyruvic acid excretion as indication of optimal requirement.

Effects of environmental temperatures of 35° C., 25° C., and 15° C. were determined by all three methods, and at 4° C. by the pyruvic acid method. The results may be summarized as follows:

1. Appetite studies revealed no effect of environmental temperatures between 15° C. and 35° C. on the thiamine requirement. The average requirement for the rats at each of the three temperatures was found to be 1.0 microgram per gram of food.

2. Food utilization experiments at 35° C. indicated a requirement of between 1.0 and 1.4 micrograms per gram of food. At 25° C. a requirement of 0.8 was observed. At 15° C. no difference in food utilization could be shown at 0.7 or 1.0 microgram levels.

3. Pyruvic acid results indicated a thiamine requirement of between 2.0 and 2.4 micrograms at 35° C. and 25° C. At 15° C. where chemical regulation of heat production had come into play for thermogenesis, the thiamine requirement fell to between 1.2 and 1.6 micrograms per gram of food. At a temperature of 4° C., where physical regulation of body temperature prevails, the requirement rose above 1.6 micrograms.

4. Activity studies revealed that maximum voluntary activity was obtained at a level between 2.0 and 2.4 micrograms of thiamine per gram of food. The greater activity of the control animals at levels below 2.0 seemed to be achieved with better food utilization since the difference in food consumption was not significant while the difference in activity was decidedly significant.

V. CONCLUSIONS

1. Lowering of environmental temperatures from the region of body temperature to 15° C decreases the thiamine requirement of the rat. When a temperature is reached where physical regulation of body temperature comes into play, the requirement rises again toward normal.

2. The maximum requirement for thiamine appears to be between 2.0 and 2.4 micrograms per gram of food. Since the highest thiamine requirements were found at the higher temperature levels, those requirements are maximal.

3. At 15° C., when no shivering occurs, the minimum requirement appears to be less than 0.7 micrograms per gram as measured by the food utilization method.

4. Exercise does not increase the percentage of thiamine required in the ration. Maximum voluntary activity occurs at the requirement level indicated by the urinary pyruvic acid excretion tests.

5. The pyruvic acid excretion test seems to be the most sensitive of the three tests used. It seems to measure the maximum requirement rather than the minimum, and therefore is probably the best measurement for practical purposes. The food utilization method is most sensitive when growth is maximal. Any factor that will limit food consumption or growth will effect the sensitivity of the method.

6. The human requirement for thiamine, based upon interpretations of the rat's requirement, is no more than 1.2 milligrams per 2500 Calories.

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VITA

Willard Bancroft Robinson was born at State College, Pennsylvania, April 19, 1918.

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